THE GYPSY MOTH IN MASSACHUSETTS

A BULLETIN OF THE
DEPARTMENT OF CONSERVATION
DIVISION OF FORESTRY

PUBLICATION OF THIS DOCUMENT
APPROVED BY THE
SUPERVISOR OF ADMINISTRATION.

INTRODUCTION

This bulletin on the gypsy moth is the successor of several that have preceded it, and the last edition, published in 1912, has been exhausted for some time. The present edition differs from its predecessors because it contains not only information on the life history and artificial methods of controlling the insect, but we have added paragraphs on its insect enemies and the wilt disease. The writer, H. O. Cook, M.F., has derived his information not only from the experience of the State Forester's department, but has drawn freely from the results of the investigative work of the United States Bureau of Entomology, and we wish especially to acknowledge the valuable assistance rendered us by Mr. A. F. Burgess, the chief of that department of the Bureau engaged in the work against the gypsy moth in New England. The aim has been to bring inside one cover, and in brief form, all the up-to-date information concerning this pest, its habits, and its control. We trust that our readers will find herein the information that they are seeking.

W. A. L. BAZELEY,
Conservation Commissioner and State Forester.

Male moth

Female moth

Male moth at rest

Female moth laying eggs

Female pupa

Full grown caterpillar

Male pupa

Egg mass

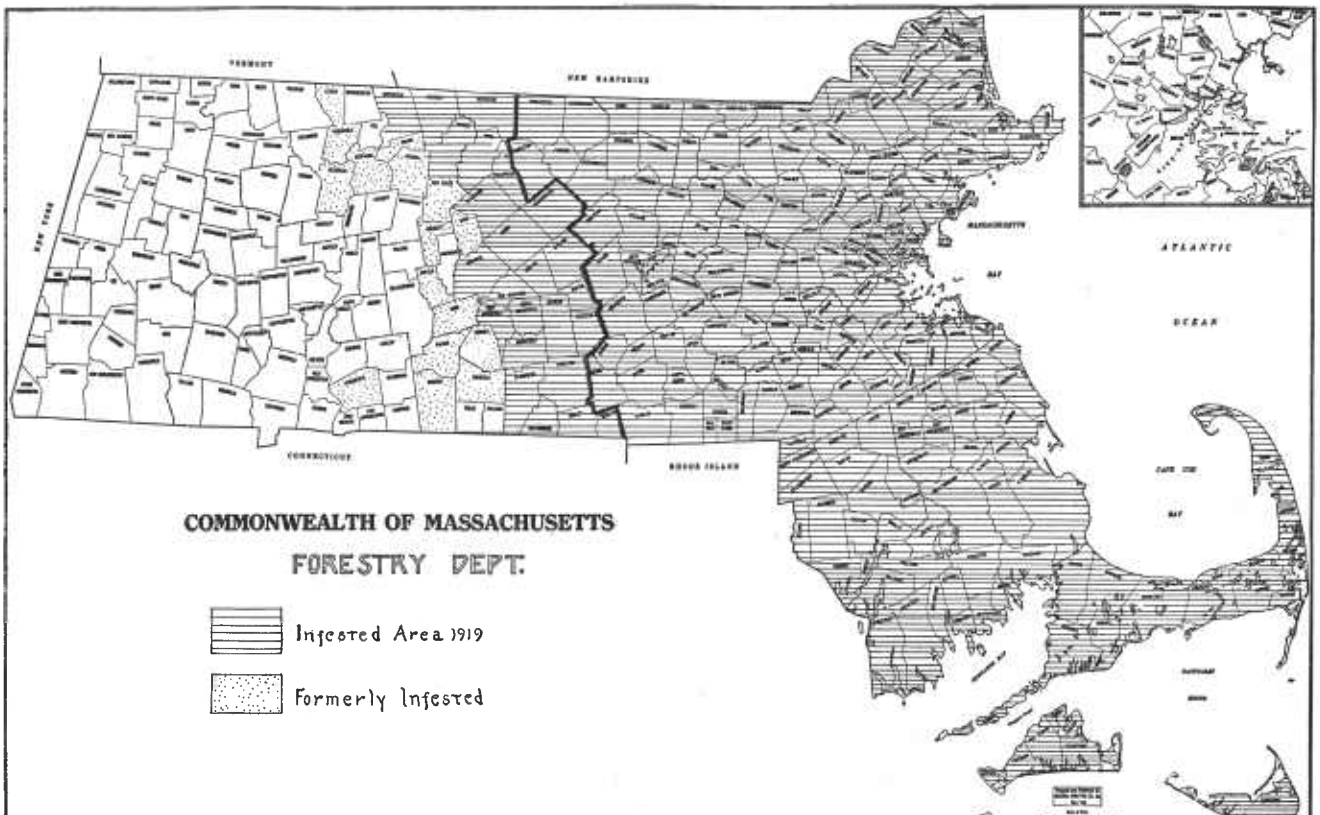
E. O. Cockayne, Boston, Lith.

L. C. C. Krieger, del.

THE LIFE HISTORY OF THE GYPSY MOTH (PORTHETRIA DISPAR).

The Gypsy Moth in Massachusetts

The gypsy moth was introduced from Europe by a naturalist, Leopold Trouvelot, in 1868, who at that time was living in Medford. Professor Trouvelot was endeavoring, by cross-breeding the gypsy moth and the silk worm, to produce a variety of the latter that could live in this climate. Unfortunately, one of the cages in which gypsy moths were confined became broken, and some of the caterpillars escaped. Mr. Trouvelot warned the people of Medford of the seriousness of the situation by articles in the local paper, but the warning was so disregarded that ten years later, when a strange caterpillar began to make its appearance in Medford, it was only after considerable investigation that it was identified as the gypsy moth of Europe. By 1889 the insect had reached alarming proportions, and a State appropriation was made to exterminate the insect. For ten years the work was carried on under the supervision of the Board of Agriculture. By 1900 the gypsy moth had been so decreased that it had ceased to be a public nuisance, and the Legislature was induced to withdraw the appropriation. This stopping of the fight against the gypsy moth was a serious mistake, for had it been continued the insect could at least have been kept under permanent control. The result of discontinuing the work was that by 1905 the depredations of the moth had again assumed alarming proportions, and they had spread over a territory far larger then they had occupied previous to 1900. In 1905 work was again taken up by the State under the supervision of a superintendent of moth work, and in 1909 the office was placed under the control of the State Forester.


VERMONT
NEW HAMPSHIRE
NEW YORK
CONNECTICUT
RHODE ISLAND
ATLANTIC
OCEAN
COMMONWEALTH OF MASSACHUSETTS
FORESTRY DEPT.
Infested Area 1919
Formerly Infested

LIFE HISTORY

The life history of the gypsy moth, like that of many insects, is divided into four stages, — egg, larva, pupa, and imago, or perfect insect.

Egg. — The eggs are spherical, yellow in color, and about the size of the head of a pin. They are laid in masses of about four hundred, on the trunks of trees, fences, stone walls, etc., and are covered by the female with yellow hairs from her body. These egg masses are laid by the female moth from about the middle of July to the middle of August.

Larva. — The larva, or caterpillar, hatches from these eggs about May 1, and when it emerges is a small, black, hairy caterpillar, less than one-quarter inch long. The caterpillar has six stages, or molts, and by the time it has reached the third molt it develops distinct markings. A double row of five raised blue spots is followed by a double row of six red. The full-grown caterpillar is from $1\frac{1}{2}$ to 3 inches long. It is the larval stage of the moth which does all the damage to foliage.

Pupa. — When fully grown, usually about the middle of July, the caterpillar spins a few silken threads as a supporting framework, casts its skin, and changes into a pupa, or chrysalis. The pupa is dark reddish brown in color, and very thinly sprinkled with brownish yellow hairs.

Moth. — From the middle of July until the middle of August the winged moths emerge from the pupæ. The male moth is brownish yellow, with dark brown markings. It has a slender body, and a wing expansion of $1\frac{1}{2}$ inches. It flies actively by day, with a peculiar zigzag flight.

The wings of the female moth are yellowish white, with numerous black markings, and expand about 2 inches. The abdomen is pale yellow and very heavy, as it is completely filled with eggs. The female is sluggish and does not fly.

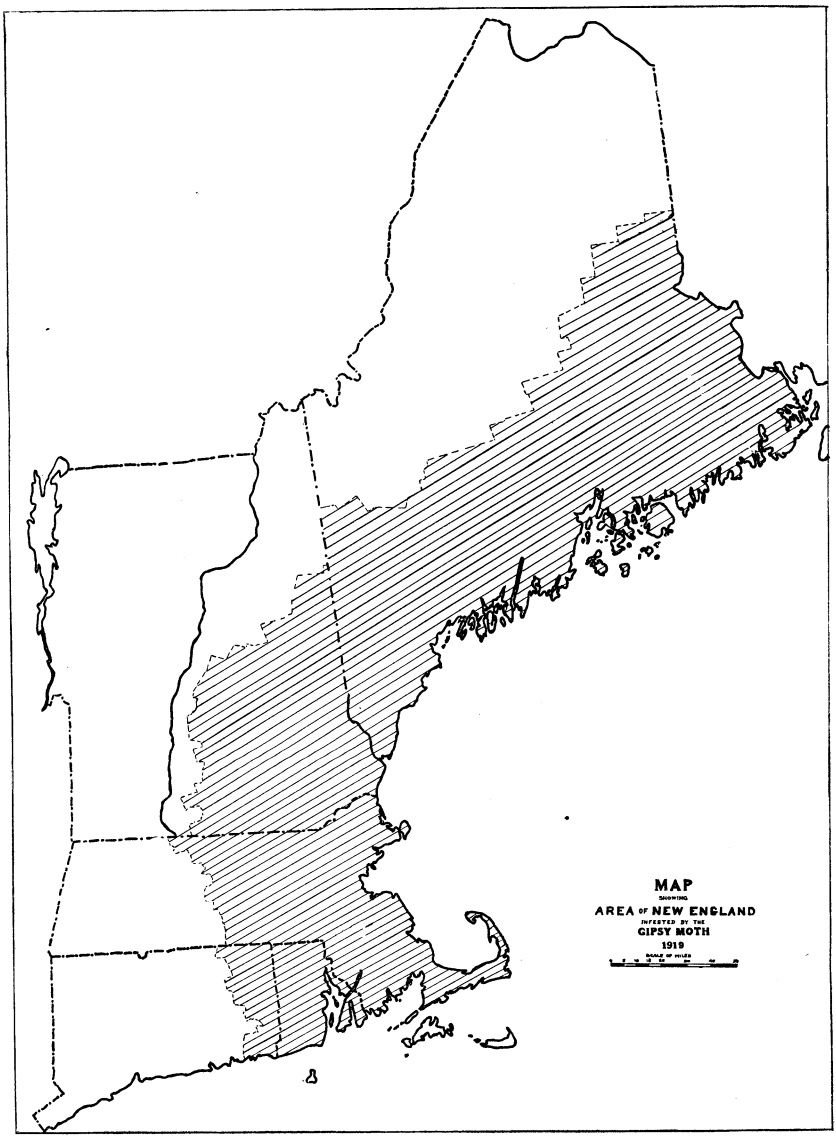
If it were otherwise, the spread of the gypsy moth would be much more rapid. After mating the moths live but a short time, and the female dies after depositing her eggs. The winged moths take no food, and all damage to foliage is caused by the caterpillars.

DISTRIBUTION

As the female moth does not fly, it is quite evident that the dispersion of this insect must be quite slow, unless it is carried by other means. The caterpillars, when first hatched, are very small — about one-eighth inch in length — and very hairy. A moderate breeze will pick up these small larvæ and carry them many miles. To test this matter the Federal Bureau of Entomology erected screens on the Isles of Shoals and at Provincetown, and on these screens small caterpillars were caught which had been blown from 13 to 20 miles. If one will notice the map of New England showing the present distribution of the gypsy moth, he will note how much farther to the northeast the moth has spread than to the southwest. This is due to prevailing southwesterly winds at the season the eggs are hatching.

When roadsides are badly infested the caterpillars may get on automobiles and other vehicles, and be carried in this way. This method of dispersion is not as prevalent as it may seem, however, and the rapid-moving automobile is less liable to transport caterpillars than the horse-drawn vehicle.

Another method of distribution of the gypsy moth is the transportation of egg-clusters on nursery stock, decorating material, and forest and quarry products. It is for this reason that the Federal government has placed a quarantine on the shipment of the above classes of materials from within the moth-infested areas to points outside, and requires that all such shipments be inspected before they can be shipped.


MAP
SHOWING
AREA OF NEW ENGLAND
INFESTED BY THE
GIPSY MOTH
1919
SCALE OF MILES

FEEDING HABITS

When the work of suppressing the gypsy moth was first undertaken the insect was considered a general feeder, and, in fact, some early experiments with laboratory feeding seemed to bear out this testimony. Long-continued field observations of the caterpillars showed, however, that they clearly favored certain species, especially the oaks, so that some very careful laboratory experiments were tried to determine just what is, and what is not, favorable food. The laboratory experiments were supplemented by detailed observations of selected areas in the field. It was found that the feeding propensities of the gypsy caterpillar change considerably with its age, and if forced to live in its early stages on what may be called "unfavorable foliage" the caterpillar could not survive and complete its life history. The result of these experiments is to place our native trees in four classes, as follows: —

I. Species favored by all larval stages: oaks, gray birch, willow, linden, larch, apple.

II. Species not favored by early larval stages: chestnut, hemlock, pine, spruce.

III. Species not favored, but which may be eaten: maple, yellow birch, elm, hickory, cherry.

IV. Species not favored by any larval stages: ash, butternut, walnut, catalpa, arbor vitæ.

The significance of this discovery lies in the fact that it aids us in part to control the ravages of the insect by forest management. By removing from our forests the favored food plants the increase of the moth can be greatly checked, and its suppression by other means assisted. The interested reader will find this matter discussed in detail in our bulletin on "Forest Thinning."

PARASITES

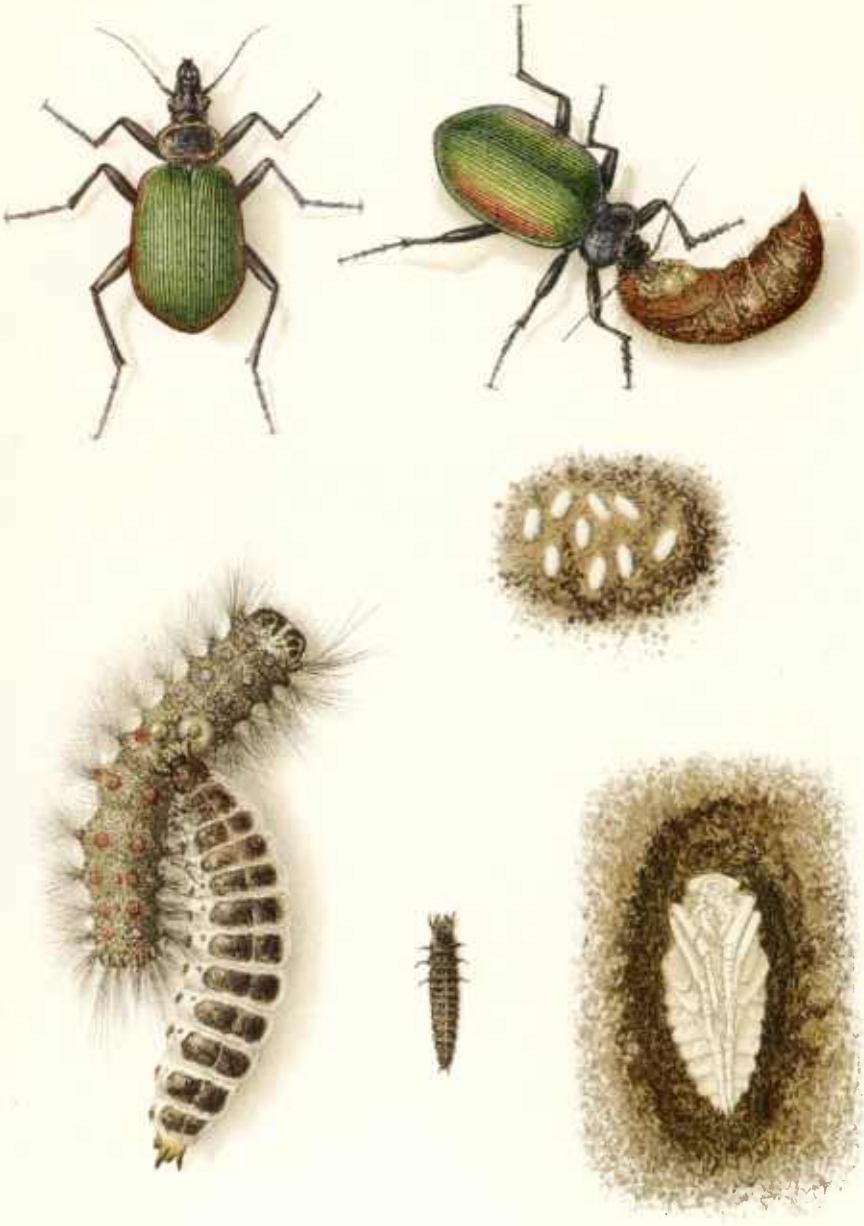
The insect world is controlled by natural forces. Were it not so, on account of their extreme power of reproduction, even one species would soon render the earth uninhabitable. To illustrate: Under the most favorable circumstances the gypsy moth will increase by sixfold in one year. Theoretically, it could increase two hundredfold, for each female moth lays four hundred eggs, and approximately half of these eggs produce female moths. What becomes of the one hundred and ninety-four eggs or caterpillars that perish by the wayside? Enormous numbers of the young caterpillars die in infancy because they are unable to obtain food soon enough after hatching, or because they are carried by the winds to places where no food exists, or because they are forced to subsist on unfavorable food. One of the potent agencies which nature uses in her control of insects is parasitism. Parasites are a class of insects which at some stage of their existence attack other insects, called hosts, and live upon them, usually internally. The importation of parasites of the gypsy moth is one of the romances of the entomological world. As this importation did not begin until 1905, and the gypsy moth came here in 1868, we must not be discouraged if the parasites have not yet increased in numbers or spread in area equally with the gypsy moth. Investigation in Europe and Japan shows that there are about thirty species of parasites feeding on the gypsy moth at some stage of its existence, and twenty of them have been imported in large numbers. Through co-operation between the Federal Bureau of Entomology and the superintendent for suppressing the gypsy and brown-tail moths a laboratory was established, first at North Saugus, and later at Melrose, to receive and handle importations of parasites. It was the largest effort in deliberate long-distance insect transportation ever tried, and it required considerable patience and investiga-

tion before satisfactory methods of transporting and rearing these insects were evolved.

It is not necessary in this bulletin to go into the life history of all these parasites, but a brief description of a few, which serve as types, may be of interest. These parasites attack the gypsy moth in three stages, — egg, caterpillar, and pupa. In fact, for parasitic work on the gypsy moth to be effective, all three stages should be attacked.

Two species of minute hymenopterous flies, *Anastatus* and *Schedius*, attack the eggs of the gypsy moth by laying their eggs within the eggs of the host. The young grubs which hatch out live on the substance of the gypsy-moth egg, thus destroying it. *Apanteles melanoscelis*, also a small hymenopterous parasite, lays its eggs in the bodies of small gypsy-moth caterpillars, and the young grubs live on the interior contents of the host until it is destroyed. There are several parasites of this class, and some of them attack the brown-tail as well as the gypsy-moth caterpillar.

The beneficial insect called the Calosoma beetle, introduced from Europe, is not a true parasite because it does not attach itself to its host. It attacks and eats the gypsy-moth caterpillars both as a beetle and as a larva. It also eats the gypsy-moth pupæ. It is voracious in appetite, active and hardy. This species has increased and spread in a most satisfactory manner, and has made great inroads on the gypsy moth in many localities. The beetles are from 1 to $1\frac{1}{2}$ inches long, and a beautiful irridescent green, while the larvæ, which are about $1\frac{1}{2}$ inches long, are shining black. There are two native Calosoma beetles somewhat similar in appearance to the imported. They are not as effective as the European species because of the inability of their larvæ to climb trees.



E. O. Cockayne, Boston, Lith. L. C. C. Krieger, del.

THE CALOSOMA BEETLES, NATURAL ENEMIES OF THE GIPSY MOTH
(CALOSOMA SCRUTATOR AND C. SYCOPHANTA).

WILT DISEASE

Infectious diseases, as well as parasites, are some of nature's means of checking the overproduction of the insect family. In fact, observations in Europe have indicated that where such disease does not exist the parasites are not able to hold the gypsy moth in check. There are several diseases affecting caterpillars, some of which are infectious and some of which are not. Of the infectious diseases none are more effective than the so-called "wilt disease." This disease is caused by a filterable virus which may affect the caterpillar at any stage, but which does not appear abundantly until the third or fourth molt. At this time the infected caterpillar loses its vitality, a brown liquid appears at the mouth and anus, and the caterpillar hangs downward, suspended by one or two pairs of feet. After death the caterpillar has a most offensive odor.

Adverse conditions of several kinds may lead to the contraction of this disease on the part of the gypsy moth, but a prime factor appears to be a decrease in the amount or nutritive value of their food. This may be brought about by an oversupply of caterpillars, which completely strip the foliage while the insects are young, or by the necessity of feeding the caterpillars on "unfavorable" food. Warm, moist weather during the feeding season seems to help in the spread of the disease. It was first thought that the disease could be artificially propagated by raising diseased larvæ in the laboratory, and liberating them among their fellows. It was found, however, that where circumstances were not propitious artificial propagation was of no avail, and that where they were favorable the disease appeared on its own account, so that laboratory propagation of wilt disease was discontinued. The disease not only kills large numbers of caterpillars, but passes with them to the pupæ. In fact, a thorough attack of wilt disease may reduce a heavy infestation of gypsy moth 80 to 90 per cent in a single season.

GYPSY MOTH IN EUROPE

Inasmuch as the progenitors of our gypsy moths came from Europe, there is much interest in the status of this insect on that continent. In Europe it has occasional severe outbreaks over restricted areas, lasting two or three years. Its outbreaks are more numerous in Hungary and in southern Europe than they are in northern Europe. This is due undoubtedly to the higher percentage of deciduous, especially oak, growth in the forests of those countries. On the whole, it is not considered to be a dangerous insect, and is not nearly as much feared by foresters as its first cousin, the nun moth (*Liparis monacha*). The reason that the gypsy moth is not as injurious in its native land, especially in northern Europe, as it is here is due to three causes, — parasitism, caterpillar diseases, and forest conditions. It takes all three factors to control an insect pest as hardy as the gypsy moth. If forest conditions, — that is, feeding conditions, are favorable to the gypsy moth, neither parasites nor disease will provide more than a temporary check. In those portions of Europe where forestry has reached a high state of development it is quite evident that the foresters have, consciously or unconsciously, eliminated the gypsy moth as a dangerous insect by greatly curtailing the growth of its favorite food. Oaks are grown only in favorable localities, in small groups, or sparsely mixed with resistant trees. Until we attain a somewhat similar condition in this State we cannot hope to have complete natural control of the gypsy moth, and must keep up the fight by artificial means.

METHODS OF CONTROLLING THE GYPSY MOTH

We have been discussing nature's methods of combating the gypsy moths by parasites and diseases, and we now come to the artificial methods of control.

Creosoting. — One of the best methods of controlling the gypsy moth is to paint the egg clusters during fall and winter with creosote, to which coal tar has been added. This is applied with a long-handled brush, and the creosote kills the eggs, at the same time staining the cluster a dark brown.[1] Unless the creosoting is to be followed by spraying it must be carefully done. If half the egg clusters are left undisturbed there will be enough caterpillars to strip the trees, and the work done is practically wasted. Where thorough spraying is carried out it is often not necessary to creosote at all, as the spray will prevent stripping. It often happens, however, where infestation is very heavy, that the young caterpillars are so numerous as to strip the foliage before it can be sprayed, and in such cases creosoting is resorted to to reduce the force of the early outbreak of the caterpillars.

Tanglefooting. — A band of tree tanglefoot about 3 inches wide may be spread around the trunk of trees to prevent caterpillars crawling up to the foliage. If the egg clusters on the trees have been previously treated, and the tree does not stand too close to untreated trees, it is an effective measure. If the caterpillars attempt to ascend the tree they mass below the sticky band and die from starvation or wilt disease.

Spraying. — The cheapest and most effective method of combating this insect in a large way is by spraying with a solution of arsenate of lead and water, using paste at the rate of 10 pounds of lead to 100 gallons of water. Many persons

[1] Creosote may be obtained in local hardware stores for 45 cents per gallon, or, in many towns, it can be purchased from the local moth superintendent for about 27 cents. These prices are the 1920 quotations, and on account of the unsettled business conditions, with which we are all familiar, are subject to change from year to year.

now prefer the powdered arsenate of lead, which is mixed on a ratio of 5 pounds to 100 gallons. It is more convenient to handle, and more economical.[1] There are a great many types and sizes of spraying machines, from a barrel pump operated by hand to the so-called high-power truck sprayer driven by a 40-horsepower truck engine. Most types of gasoline sprayers are designed for orchard use, and cannot be used on street and woodland trees unless climbing is resorted to, — an expensive method. A satisfactory high-power sprayer drawn by two horses has a 400-gallon tank and a triplex pump capable of delivering 35 gallons per minute at 200 to 250 pounds' pressure. Such a machine throws a stream 70 to 80 feet in the air, and in woodland work a length 1,500 feet of hose is frequently used with success. This pump is driven by a 4-cylinder 10-horsepower engine.[2] The cost of spraying is very variable, and depends on several factors, the chief of which is the distance which it is necessary to traverse in going for water to fill the tank. Even under favorable circumstances about half the time is consumed in this operation. In woodland the cost varies greatly, dependent on the conditions. Woods that have been thinned, and underbrush cleared, can of course be sprayed much cheaper than woodland uncared for. An abundance of roads, making all parts of the woodland easily accessible, reduces the cost by making it possible to reach all sections with a short hose. Where a central water supply, as a pond or brook, is available, it is better to station the sprayer at this point, and reach all parts of the woodland by use of a long hose rather than to haul the water. In general, woodland spraying costs from $10 to $15 per acre, and as much woodland is valued at less than this amount it is hardly practical to

[1] In hardware stores paste arsenate, in small lots, costs 40 cents per pound, but in many towns it can be purchased from the local moth superintendent for 12 or 13 cents per pound, and the dry powdered for 27 cents. These prices are the 1920 quotations, and on account of the unsettled business conditions, with which we are all familiar, are subject to change from year to year.

[2] It costs about $40 per day to operate such a machine.

spray the average woodland. The cost of roadside spraying, if figured at the cost per tree, will depend on the number of trees per mile of road and their size. In general, the cost of spraying ornamental roadside trees is about 25 cents per tree, — an investment well worth making. Of course the above costs are average, and subject to wide variations. They also apply only to operations carried out on a large scale. The cost of spraying two or three acres of woodland, or a few ornamental trees around a house, would be much higher, as allowance must be made for time lost in getting out the machine and going to and from the job.

One of the chief difficulties in spraying for the gypsy moth is the shortness of the time allowed for the job. The feeding season of the caterpillars extends from the middle of May until the middle of July, but spraying cannot well commence until the trees are in full leaf, which is not until the 1st of June, and spraying done after the 1st of July is not very effective, for the larvæ have already done their worst damage, and the foliage may be so badly stripped as to be incapable of holding the poison. It is not possible to spray in wet weather because the poison will not stick to the foliage, and it is difficult, at least, to spray in windy weather, so that there is sure to be considerable lost time to be taken out of the one month of spraying season.

The proper method of handling the gypsy moth in woodland or shade trees, orchards, or parks should be based on the infestation as determined by some one who is familiar with the work. Much energy and money may be wasted in applying remedies, unless their application is based on a thorough knowledge of existing conditions. An owner of an infested estate should apply to the State Forester to have an examination made by one of his assistants, who not only can give him reliable information as to the proper treatment, but, under some conditions, will assume responsibility for seeing that the work is carried out.

ADMINISTRATION OF WORK

The laws regulating the work against the gypsy moth are published in a separate publication, and will not be reprinted here, but a brief statement of the method of carrying on the work will be of value in this bulletin.

The law provides that each individual town shall care for the suppression of the gypsy and brown-tail moths within its borders through a local superintendent appointed by the mayor or selectmen, with the approval of the State Forester. In carrying out the measures for such suppression the local superintendent acts under the direction of the State Forester and his district superintendent. The financing of this work, as provided by law, is somewhat complicated, and need be only briefly outlined here. Each town is required to expend one twenty-fifth of 1 per cent of its valuation in suppressive work. This sum, which amounts to only a few hundreds in small towns, and runs up to a maximum of $5,000, the community must spend from its own funds, provided conditions call for it. Where an amount in excess of this liability is spent by the towns the whole or a portion of said excess may be reimbursed to the town by the State, the percentage of such reimbursement depending on the valuation of the town. Such reimbursements are paid partly in money, but supplies also constitute part of the amount, because it is possible for the State Forester to buy materials in large quantities much cheaper than the towns, and economy in disbursing the State appropriation is thus secured.

In addition to the work done under the direction of the State Forester, the Federal government appropriates $300,000 per year for the suppression of the gypsy moth. This work is done by the Federal Bureau of Entomology, and although their territory includes all New England, a considerable portion of their funds are expended in Massachusetts. By agreement between it and this department it

undertakes the work of stopping the spread of the moth by work on the frontier of the infested territory. The work of controlling the gypsy moth west of the heavy line shown on the map of this State is in the hands of the Bureau of Entomology. They have assumed the responsibility for all work of a scientific character, such as parasite importation and investigation in field and laboratory of various conditions affecting the life of the gypsy moth. They also have charge of the inspection of the shipments of forest products mentioned before. Because they are not restricted by State lines they are better able to carry on this line of work than the State Forestry Division.

BIBLIOGRAPHY

For the benefit of those who may wish to study into certain phases of the gypsy-moth problem more thoroughly than the present bulletin gives opportunity, we append this list of Federal and State bulletins. It is only fair to state that many of these publications give the result of earlier investigations, and do not contain the most up-to-date information on the subject that they are supposed to cover.

State Forester: —

Parasites of the Gypsy Moth.
Wilt Disease of the Gypsy Moth.
Management of Moth Infested Woodlands.
Calosoma Beetle (card in colors).

United States Department of Agriculture: —

Farmer's Bulletin (564) Gypsy Moth, with Suggestions for its Control.

Bureau of Entomology Circular: —

(164) Gypsy Moth as a Forest Insect.

Bureau of Entomology Bulletins: —

(273) Dispersion of Gypsy Moth Larvæ.
(251) The Calosoma Beetle in New England.
(250) Food Plants of Gypsy Moth in America.
(204) Report on Gypsy Moth in New England.
(484) Control of Gypsy Moth by Forest Management.
Wilt of Gypsy Moth Caterpillars. Journal of Agri. Research 1915, Vol. IV, No. 2.

Horse-drawn sprayer equipped for service.

Trees on right sprayed; on left not sprayed.

Spraying ornamental trees.

Spraying in woodland.